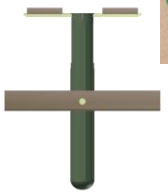
Robert Klenke, Ph.D.

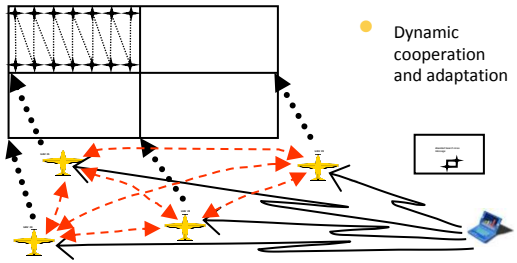
Professor

Department of Electrical and Computer Engineering

VCU Unmanned Aerial Systems (UAS) Research Projects

- Flight Control System Projects
  - NASA Langley – AirSTAR project
    - advanced autopilot architectures
  - Army Research Lab
    - advanced autopilot architectures
  - Barron Associates – NASA, U.S. Navy, and U.S. Army
    - miniature autopilot architectures
    - autopilot GNC software development
    - development and operation of lift aircraft for vehicle flight testing
    - flight testing mission support
  - IR&D
    - autopilots, networks, and algorithms for heterogeneous UAS collaborative teams

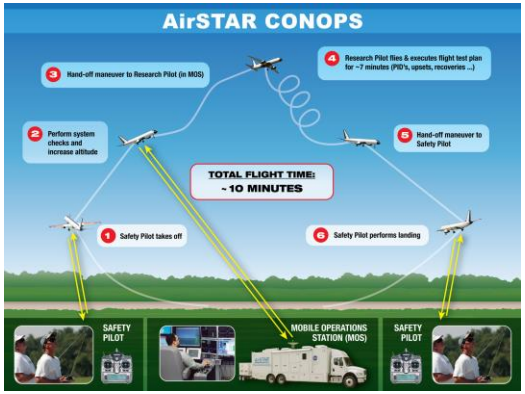


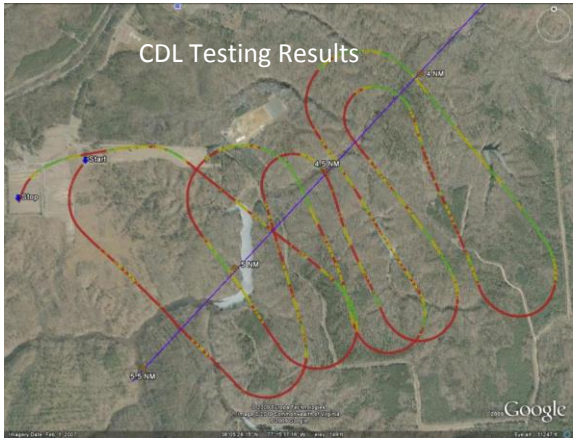


Two UAVS on a collaborative surveillance mission

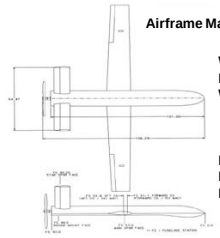
VCU Unmanned Aerial Systems (UAS) Research Projects

- Data Payload Projects
  - NASA Langley – AirSTAR project
    - flight data recorders/translators
    - flight testing mission support





  - Mitre Corporation – U.S. Army and Marine Corps
    - digital video payload system
    - digital datalink testing
    - flight testing mission support



Airframe Manufacturer: Griffon Aerospace

Wingspan: 13.6 feet
Length: 9.0 feet
Weights: 83 lbs dry *
95 lbs wet *
120 lbs maximum

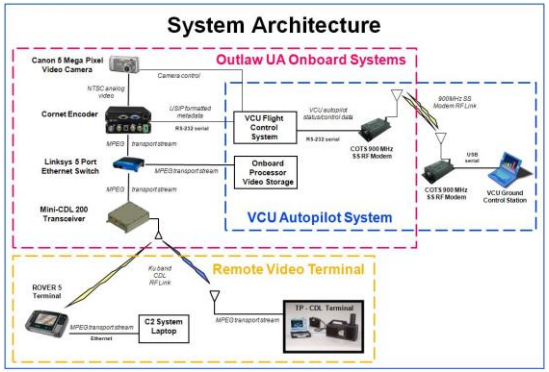
Engine: DA-150 17 hp
Propeller: Xoar 28 x 14
Fuel: Gas/Oil mix
2 gal* to 7.5 gal

Endurance: 3 - 4 hours maximum
1 - 1.3 hours*

Speed: 110 knots maximum – 40 knots minimum
70-80 knots cruise*

Electrical Power: 3.7 Ah, 18 V (Video/Data Link Payload)
3.0 Ah, 7.2 V (Receiver and Servos)
1.7 Ah, 12 V (Flight Control System)
12 Ah, 6 V (DA-150 Ignition)

* as equipped



Cyber Security for sUAS Flight Control Systems

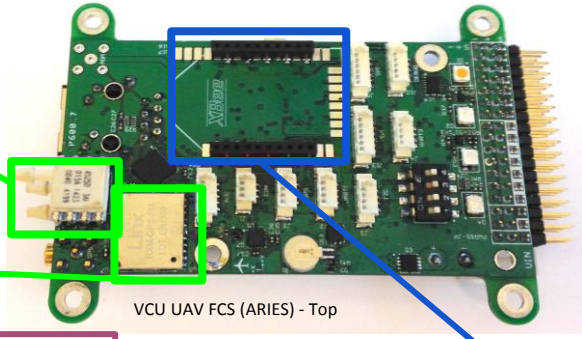
Main Processor Attacks
- Firmware
  - Developer, Maintenance
  - PID Gain Scheduling
  - Sensor Parsing
  - Initialization
  - Configuration

Sensor Attacks
- Firmware
- External (Spoofing)
- False Data Injection
- Lock internal communication bus (I2C)

Absolute Baro
Differential Baro

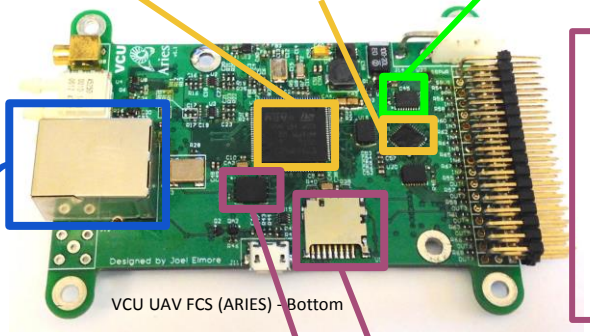
Inertial Measurement Unit (IMU)

GPS



Main Processor

Safety Switch Processor



Storage
- Corrupt Configuration stored in Flash
- Corrupt Stored Parameters in Flash
- False Read from SD Card
- Log incorrect data to SD Card

Xbee
(Serial UART Modem)

Wireless Communication Attacks
- Jamming
- Sending False Parameters/Configuration
- Hijack Waypoint Navigation

SD Card

External Flash

Ethernet
(UDP Modem)

sUAS Projects – Undergraduate Student Involvement

- Vertically Integrated Projects (VIP) – 20 undergraduates working in the UAS lab on multi-semester projects
  - Safety Pilot Dashboard
  - Wireless Network
  - Skyhunter video payload
  - Target recognition
  - FCS for multi-copter
  - AUVSI competition
  - Small Collaborative UAS
  - Cyber Security
- AUVSI Student UAS Competition
  - Continuous participation since 2003
  - Over 30 students have been team members
  - A number have gone onto UAS-related careers

MicroUAS for Environmental Remote Sensing and Mapping

William Shuart, M.S.

Center for Environmental Studies at VCU

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www.vcu.edu/rice

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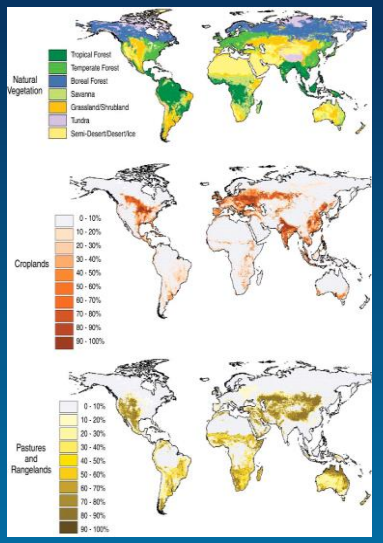
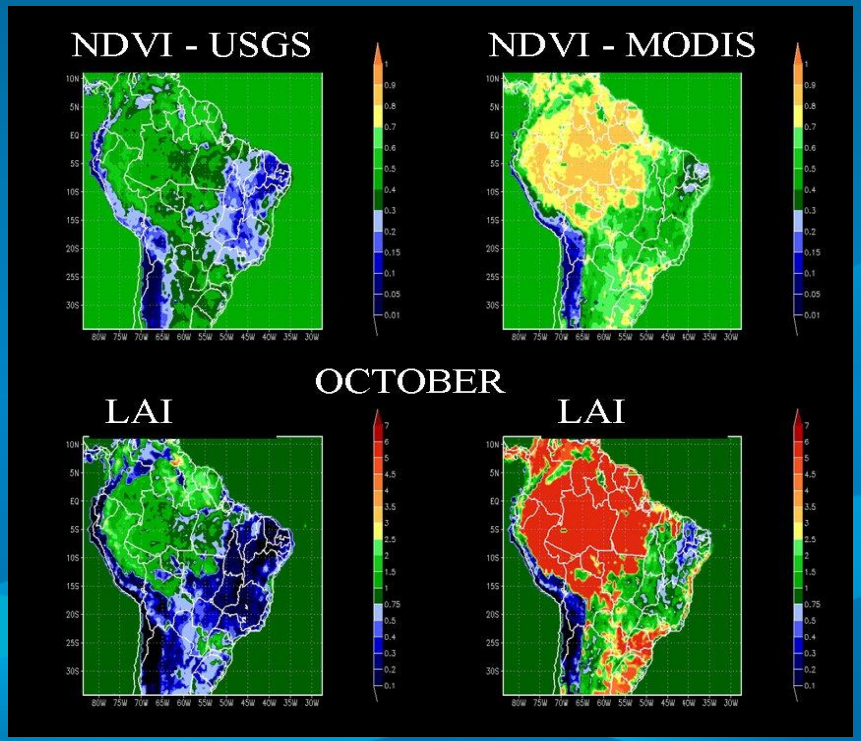
Rice Rivers Center

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object. - Jensen.

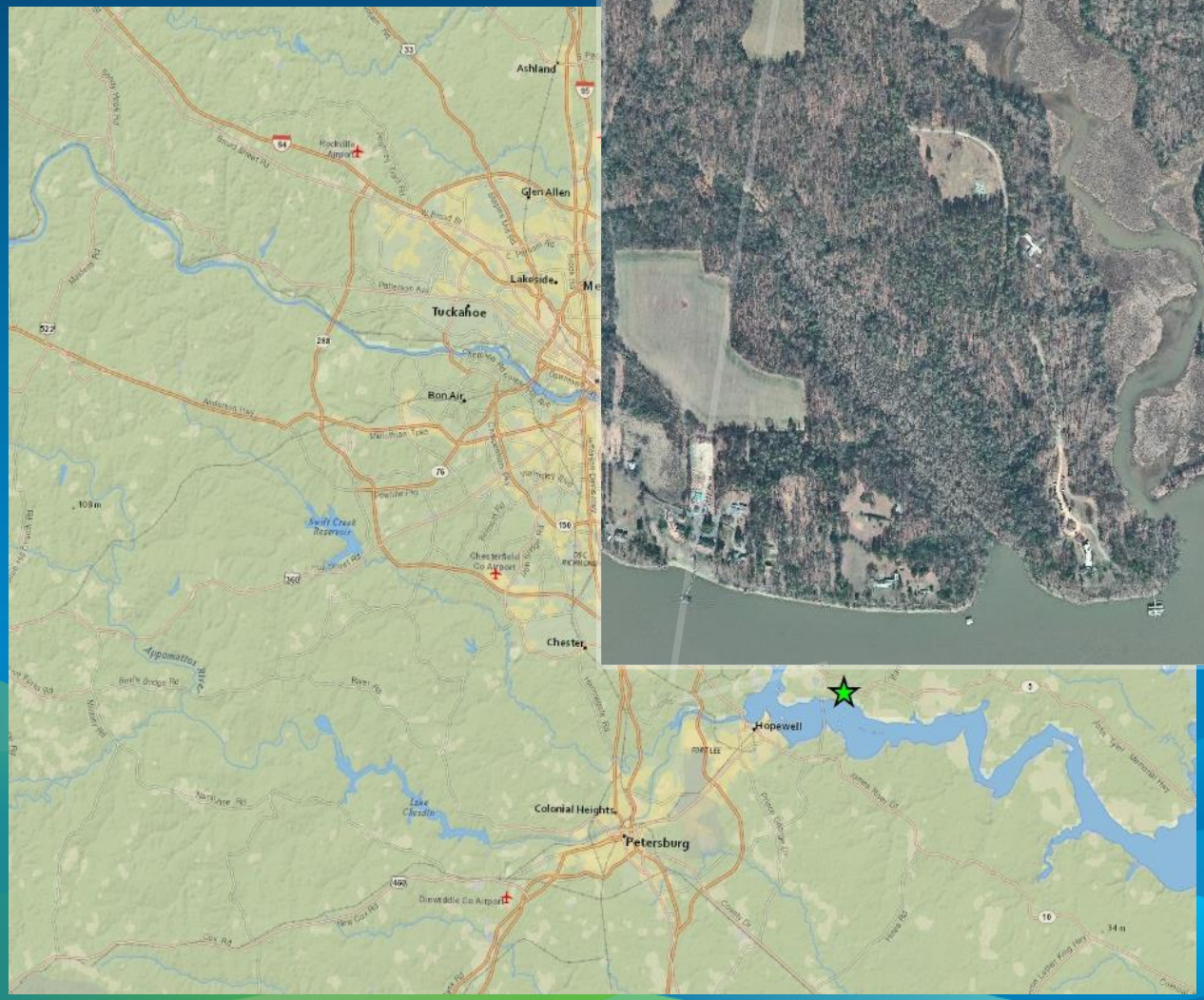
1. Land cover classification
2. Vegetation health
3. Turbidity aquatic systems
4. Water temperatures
5. Soil moisture
6. Precision agriculture
7. Minerology
8. Emergency response (oil)
9. Thermal change





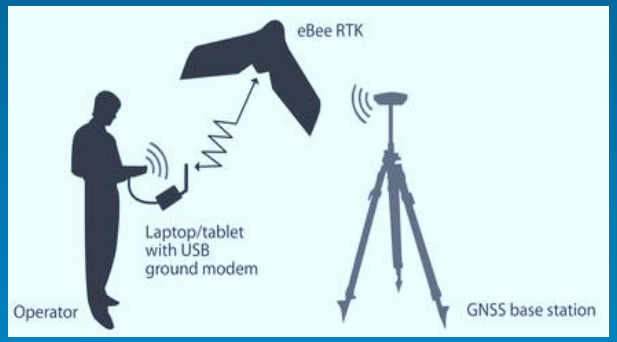
http://brams.cptec.inpe.br/resources/images/NDVI

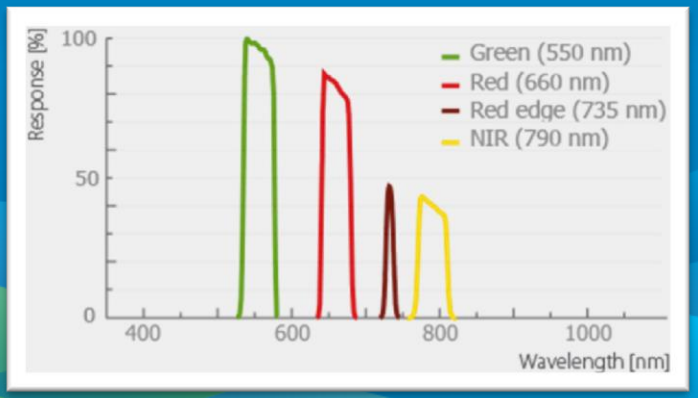
Case Study: VCU Rice Rivers Center
Location: Charles City, Virginia
Purpose: Characterize and Map Vegetation Health
Date: August 2015



Hardware: senseFly eBee RTK

- Real-time Kinematic GPS (Survey Grade)
- Global Navigation Satellite Systems
  - L1/L2 GLONASS GPS Receiver
- RGB, NIR, Red-Edge Cameras
  - Multispectral and thermal
  - 18mp, 3cm/5cm
- Fully Autonomous
- 1.5 lbs
- 40 minute endurance
- 2km radius



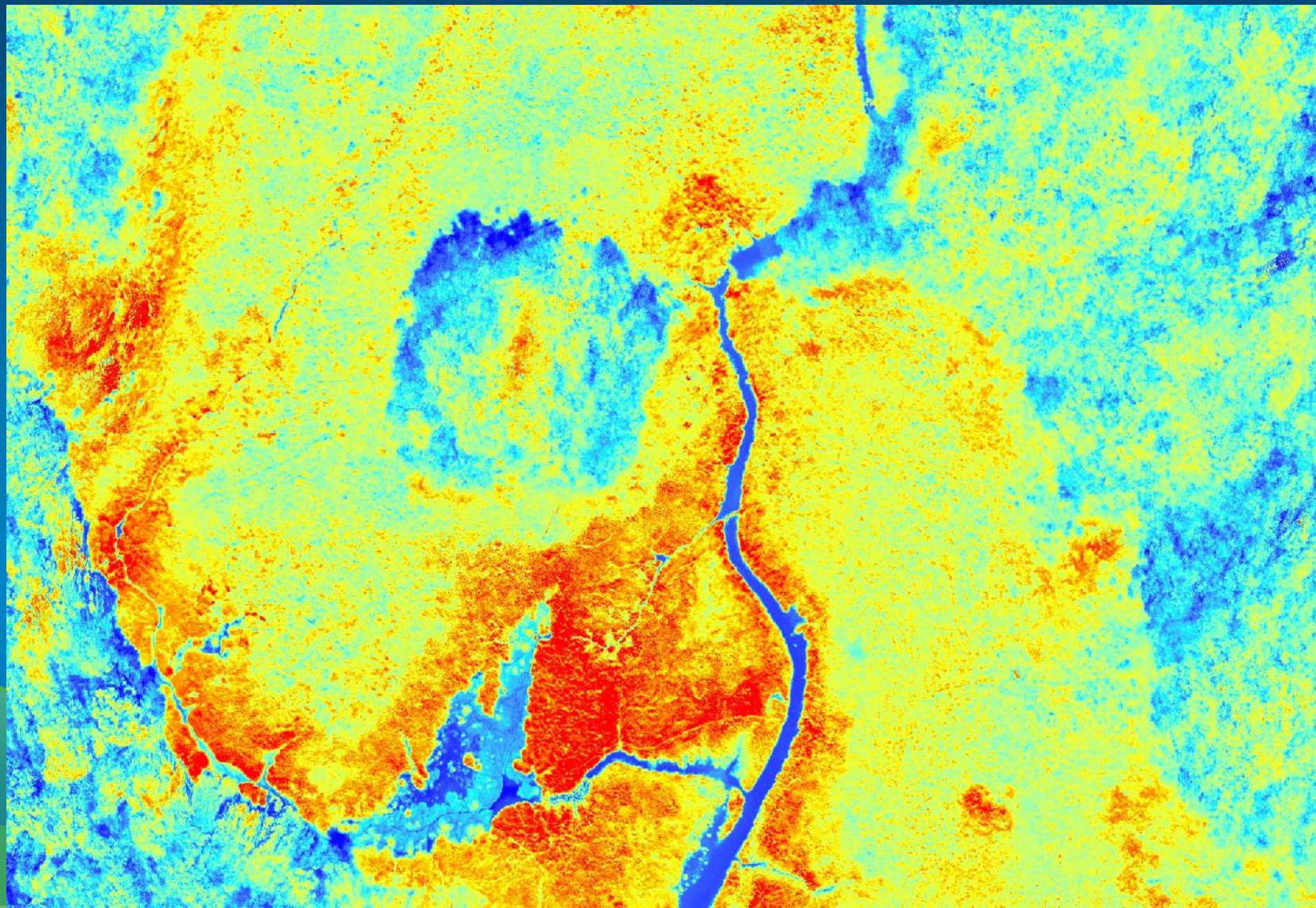


Results: RGB Camera visually shows areas of turgid/healthy vegetation

With just RGB data, quantifying biomass and other Indices are not possible

Solution: Near-IR and Red-Edge Camera Data

Near IR data shows structural biomass while the red-edge sensor detects light being absorbed for photosynthesis. A ratio is then computed to determine the amount of photosynthetic light absorbed vs the actual biomass detected.



VCU's Robertson School of Media & Culture

- Exploring use of UAS in newsgathering, documentaries, advertisements and other media content
- Have integrated the concept (but not hands-on use) of UAS into journalism and other courses
- Offered a course (Spring 2015) in which students submitted comments to the FAA on its proposed UAS rules

Drones in Journalism and

rampages.us/mediadrone/

DRONES IN JOURNALISM AND OTHER MEDIA INDUSTRIES

for honr 399-701, a vcu course on the "eye in the sky"

Search

SEARCH FOR:

Search

RECENT POSTS

- Talk at UR about drones
- We've posted our comment to the FAA
- Learning how to fly a drone
- Drones in Virginia Beach
- Drone lessons

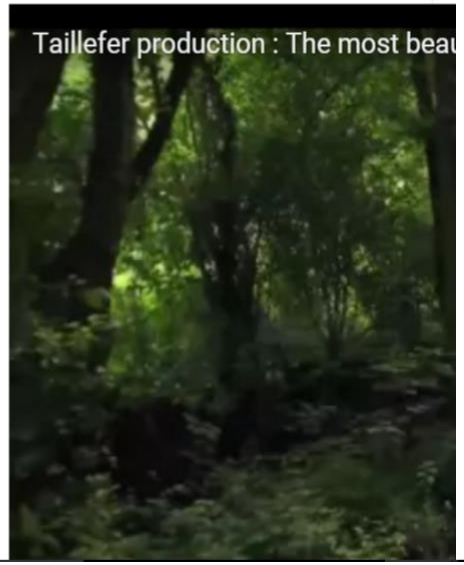
RECENT COMMENTS

PRESENTATION

TALK AT UR ABOUT DRONES

17 NOV , 2015

A few examples:



WHITE PAPER

WE'VE POSTED OUR COMMENT TO THE FAA

24 APR , 2015

We've posted our comment and our research paper on Regulations.gov regarding the FAA's proposed rule governing the commercial

CLASS

LEARNING HOW TO FLY A DRONE

23 APR , 2015

Florina found a helpful video tutorial on how to fly a drone. As she said on her blog, this might be a model of the type of skills someone would have to demonstrate in order to get a UAV license.

Regulations.gov - Comme

www.regulations.gov/#!documentDetail;D=FAA-2015-0150-4025

regulations.gov

Your Voice in Federal Decision-Making

C Jeff South

This is a Comment on the **Federal Aviation Administration** (FAA) Proposed Rule: **Operation an**
Unmanned Aircraft Systems

For related information, **Open Docket Folder**

Comment

These comments are being submitted by a group of Honors students at Virginia Commonwealth
studying commercial drone use and the FAA proposed rules during the spring semester. We focu
could use UAVs in safe and responsible ways that would benefit their industries. We have attach
these issues. Here is a summary of our comments regarding specific rules proposed by the FAA.

We agree that safety is paramount in the operation of drones, whether for commercial use or by h
the FAAs proposals, including: prohibiting UAVs from going higher than 500 feet; prohibiting the
prohibiting flying drones with only first-person view; requiring the UAV operator or a spotter to ma
UAV; and restricting flights over any persons not directly involved in the operation of the UAV.

At the same time, we believe the FAA should consider modifying some of the proposed rules or a
before final adoption of the regulations. In our paper, we have elaborated on the following points:

The FAA should consider grouping UAVs by weight into distinct classes, with appropriate rules fo
a version of the UAS America Funds Micro UAS rules.

The FAA should encourage if not require all UAV manufacturers to include GPS and return to home when the battery gets low
systems (which many drone models already have). This technology also could be used to promote safety in response to adverse

Country:
United States

UAS_paper_and_FAA_com

file:///C:/Users/Jeff%20South/Downloads/UAS_paper_and_FA

- Operator must maintain a sUAS in conditions for safe operati
  aircraft prior to flight
- Aircraft registration required
- Aircraft markings required

Our Class' Analysis and Recommendations Regarding Select R

Our class took a more in-depth look at certain proposed rules regard
(the device), the drone operator (pilot) and drone operations (flying)

Weight limit on drones

One section of the proposed rules that has drawn major attention fr
current weight restriction. It can easily be argued that a 5-pound dro
drone will fly differently, be operated differently, have different capab
different safety concerns, yet the current rules lump all UAVs up to 5
same set of rules.

One mitigation to this rule may be to instead group UAVs by weight
with appropriate rules for each class. Hobbyist drones rarely go ove
even with attachments and added parts. The hobbyist class could ra
UAVs to the standard hobbyist sized UAV from approximately 0-10
reasonable to have laxer rules on drones of this size since they are
somebody due to their insubstantial weight. When using drones for
purposes, as in various forms of journalism, they usually have extra
on to enhance their features and provide quality video, which adds t
commercial drone class could range from about 10-25 pounds, whic
gap for adding extra features to the UAV while still remaining at a re

Robertson School: Future plans

- Waiting for FAA to adopt rules for commercial use of UAVs; hoping rules won't require pilot's license
- Three faculty members already fly UAVs as hobbyists
- Our hope is to teach students how to safely, legally and ethically fly UAVs for creating media content